STANDARD OPERATING PROCEDURE

Title:	Fracture Characterization	Identifier: ~~SOP~~ ER-SOP-3.06	Revision: 1	Effective Date: 8/26/98

ER PROJECT

APPROVALS FOR USE

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LOS ALAMOS NATIONAL LABORATORY

FRACTURE CHARACTERIZATION

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NOTE: ER Project personnel may produce copies of this procedure from the controlled document electronic file. However, it is the user's responsibility to assure that they are trained to and utilizing the current version of this procedure. The procedure author may be contacted if changes are unclear.

1.0 PURPOSE

This procedure states the responsibilities details the methodology to be applied for characterization of all natural rock fractures in the Bandelier Tuff at the Los Alamos National Laboratory Environmental Restoration (ER) Project.

NOTE: Through application of this standardized approach, field studies of the Bandelier Tuff can give statistically significant measurements of (1) linear density of rock fracture, (2) fracture width, (3) fracture strike and dip, and (4) nature of fracture filling materials. The fracture characterization plots and data table that result from this study constitute sufficient documentation of rock fracture to locate possible fault zones, tectonic and compaction deformation amounts, density of fractures contributing to fracture permeability, and overall competency of the Bandelier Tuff. The primary intent of this standardized approach is to make fracture characterizations from various field studies compatible such that fault zones from one field area to another can be correlated.

2.0 TRAINING

2.1 All users of this SOP are trained by self-study, and the training is documented in accordance with QP-2.2, Personnel Orientation and Training.

2.2 The **Field Team Leader** (FTL) will monitor the proper implementation of this procedure and ensure that relevant team members have completed all training assignments (see Section 7.0) in accordance with QP-2.2, Personnel Orientation and Training.

2.3 Completion of a college-level course in field geology and a laboratory/lecture course in structural geology is required to use this procedure. In addition to fulfilling the requirements of this procedure, familiarity with the computer database RS/1 or similar system is necessary.

3.0 DEFINITIONS

3.1 ***Fracture*** - The term "fracture" refers to any natural, linear to curvilinear break in the Bandelier Tuff without regard to the origins of the break. Displacement or opening of the break may exist but is not necessary.

Terms having similar connotation for this work are "joint" or "crack." A fracture along which significant displacement has occurred is a "fault." The level of significance required for this designation depends upon locality and geological structure.

4.0 BACKGROUND AND PRECAUTIONS

4.1 Fracture analysis in volcanic tuff follows techniques described in the structural geology text by Dennis (1972). An example document that describes a fracture characterization study on the Bandelier Tuff, using this procedure is by Vaniman and Wohletz (1990).

4.2 The main caution that must be taken in this procedure to avoid error is measurement of fractures along traverses where fracture exposure is uniform. The recognition and documentation of a fracture is dependent solely upon the researcher's ability to measure its strike, dip, and opening. In many cases these measurements require projection of the fracture plane by visual alignment. The statistical methods of fracture interpretation are intended to minimize uncertainty in these measurements. Judgement is a critical aspect of field geology and is covered in the text by Compton (1962) and the procedure covering field work SOP-03.09, Geologic Mapping of Bedrock Units.

5.0 EQUIPMENT

Fracture documentation and measurement requires a Polaroid camera to make prints for documenting fracture location, a tape measure, a brunton compass, a geological pick to clear debris from fracture surfaces, a hand lens to identify fracture-filling materials, and a flexible cardboard or plastic sheet that can be inserted into fractures to aid in projecting their strike and dip.

6.0 PROCEDURE

Note: Deviations to SOPs are made in accordance with section 4.9 of ER-QP-4.2, Standard Operating Procedures Development.

Three phases are required by this methodology: (1) photographic documentation of area or traverse along which fractures will be characterized, with construction of a photomosaic map base; (2) measurement of fractures and their plotting on the previously constructed fracture map; (3) entering fracture data into a computer data base and their analysis by designated procedures; and, (4) Data will be transmitted to FIMAD in accordance with QP-5.7, Notebook Documentation for Environmental Restoration Investigations.

6.1 Photo Documentation

Once a traverse or area has been identified for fracture characterization, noting the above caution that fractures should have uniform exposure, a photo mosaic map of the traverse is constructed using a Polaroid camera. In order to maintain a uniform scale and resolution for this photo mosaic base the distance from the camera lens to the exposure should be held within ± 10%. Generally this distance is on the order of 40 to 60 feet such that the edges of the photo will have a lateral scale within ± 10% of that of the photo's center. Successive photos should be overlapped sufficiently to maintain this scale requirement. Also the scale should provide enough visual resolution that major fractures are easily identified on the photo. Typically this scale requirement is that each photo will cover from 10 to 30 horizontal feet of fracture exposure.

After construction of the photomosaic, tracing paper is overlaid to make a map of outcrop features including key topographic points such as cliff tops and bottoms, prominent fractures, and geographic objects such as buildings, trees, and large sign posts. This map should be attached to the base of the photomosaic such that a one-to-one correspondence can be made between mapped and photographed features.

6.2 Fracture Measurement

Using the fracture map constructed from photomosaics, the fracture traverse is measured using a tape measure; a horizontal scale is then placed upon the map that shows the distance between mapped features. This scale will have some horizontal variability because of the map projection method and photographic error. The scale reliability should be ± 10%. Starting from one end of the fracture traverse, each fracture is sketched upon the map and designated by a number. Fracture strike and dip are measured to an accuracy of ± 1 degree with the brunton compass along with a measurement of fracture opening width (measured perpendicular to fracture surfaces). These data are recorded in a field notebook with the fracture number along with a description of any unique features of the fracture, such as nature of fracture filling materials if present, oxidation or mineralization on fracture surfaces, and cross-cutting relationships with other rock features (pumice or lithic clasts, textural features that might be used to estimate movement along the fracture).

6.3 Fracture Data Base and Analysis

The fracture data recorded in the field notebook are entered into a data base, which allows application of several statistical procedures. The RS/1 data base system is suggested for this work but other systems can be adapted. The data base consists of a table with column for each fracture listing the fracture's number designation, its horizontal location shown on the fracture map, its dip and strike, and its width. From these data several other columns are statistically calculated, including: (1) a linear fracture density calculated as a moving average by counting the number of fractures contained in a given distance interval (10 and 100 feet) centered on each fracture; (2) a cumulative fracture width over a specified interval (10 and 100 feet) centered on each fracture; and (3) relative dip of fracture from vertical where negative values indicate southerly inclinations. Because fractures in the Bandelier Tuff are generally part of conjugate sets of northwest and northeast trending systems, additional columns for the table are separately calculated for each of the three above columns for each conjugate set. The RS/1 procedures for the above calculations are archived as source and compiled codes on essxrf VAX under RS/1 directory [wohletz]@ken@ta55. The procedures are: (1) DENS -- calculates linear fracture densities for several different distance intervals; (2) DIP -- transforms dips measurements to degrees from vertical; and (3) WID -- computes cumulative fracture widths for several distance intervals.

Fracture data are then graphed on several different plots. (1) Fracture density (10 and 100 foot intervals) vs horizontal distance along the traverse; (2) Histograms or rose diagram of fracture strike; (3) Fracture strike vs horizontal distance where positive strikes represent strike in degrees east of north and negative strikes are west of north. These data are smoothed using the RS/1 data smoothing option to show the trend of northeast and northwest fracture sets as well as the overall trend of all fracture strikes; (4) Fracture dips vs horizontal distance where vertical plots at zero, dips toward the northeast or northwest are positive inflections from vertical, and southerly dips are negative inflections from vertical. Again smoothing of data show average trends for fracture sets; (5) Fracture widths vs horizontal distance with smoothed trends for fracture sets; (6) Cumulative fracture widths (per 100 foot interval) vs horizontal distance with smoothed trends for fracture sets; and (7) Fracture widths greater than 10 cm versus horizontal distance.

7.0 REFERENCES

Compton, R.R. (1962) Manual of Field Geology. John Wiley & Sons, New York, 378 pp.

Dennis, J.G. (1972) Structural Geology. The Ronald Press Co., New York, 532 pp.

Vaniman, D. and Wohletz, K. (1990) Results of geological mapping/fracture studies: TA-55 Area. Los Alamos National Laboratory, Seismic Hazards Program Memo, EES1-SH90-17, 48 pp.

LANL-ER-SOPs in ER SOP Manual Section 1.0, General Instructions
LANL-ER-SOP-3.09, Geologic Mapping of Bedrock Units

QP-2.2, Personnel Orientation and Training
QP-5.3, Records Management
QP-5.7, Notebook Documentation for ER Investigations

8.0 RECORDS

The **Field Team Leader** submits the following records to the Records Processing Facility in accordance with QP-4.3, Records Management.

8.1 Daily Activity Logs (Laboratory Notebooks)

8.2 RS/1 Computer Database

8.3 Photographic Documentation

9.0 ATTACHMENTS

None.

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REVIEWER CONCURRENCE

I have reviewed the final version of this procedure, and my comments (unless exceptions are noted) have been satisfactorily resolved and the results incorporated as agreed upon with the author.

PRINTED NAME	SIGNATURE	EXCEPTIONS*	DATE
DAVID BROXTON	David Broxton		8/18/98

***Instructions for "EXCEPTIONS" block**. Enter information regarding your comments that were not satisfactorily resolved with the QP author.